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PRELIMINARY REPORT

ON THE

GEOLOGY OF ALBANY COUNTY

By N. H. DARTON

[FROM REPORT OF THE STATE GEOLOGIST FOR THE YEAR 1893]

(Map not published)

ALBANY
JAMES B. LYON, STATE PRINTER
1894

PRESENTED BY
THE AUTHOR

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GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.

(GEOLOGICAL MAP.)

PRELIMINARY REPORT

ON THE

GEOLOGY OF ALBANY COUNTY.

JAMES HALL, STATE GEOLOGIST. | N. H. DARTON, ASSISTANT.

1892-1893.

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GEOLOGICAL SURVEY OF THE STATE OF NEW YORK.
(GEOLOGICAL MAP.)

Preliminary Report on the Geology of Albany County.

BY N. H. DARTON.

CONTENTS.—PHYSIOGRAPHY. *General relations; The great plain. The Helderberg escarpment. The Southwestern townships.* GENERAL STRUCTURAL RELATIONS. STRATIGRAPHY; *Oneonta formation. Hamilton flags and shales. Hamilton black shales. Onondaga limestone. Schoharie grit. Esopus shales. Oriskany sandstone. Becraft limestone. Shaly limestone. Pentamerus limestone. Tentaculite limestone. Salina waterlime. The unconformity. Hudson river formation.* STRUCTURE. PLEISTOCENE GEOLOGY.

PHYSIOGRAPHY.

JAMES HALL, *State Geologist:*

SIR.—Albany county, in central eastern New York, has an area of approximately 550 square miles. It has a frontage of about twenty-four miles on the Hudson river from north of the Mohawk river to below Coeymans Landing, and extends about twenty-five miles westward. It is bounded on the south by Greene county, on the west by Schoharie county, on the north by Schenectady and Saratoga counties, and on the east by the Hudson river which separates it from Rensselaer county. It is separated from Saratoga county by the Mohawk river.

Topographically the country comprises three principal provinces ranging in altitude from tide water along the Hudson river to 2200 feet to the southwestward. They are, first, the elevated plain extending from the banks of the Hudson and Mohawk rivers over the eastern and northeastern townships, to a line passing from near Coeymans Junction through Altamont, with an area approximately of 200 miles; second, the Helderberg escarpment, a line of high cliffs arising abruptly from the plain, along

its western margin and surmounted by a plateau and terraces of variable width; third, a wide area of high rolling hills and terraced ridges presenting a steep front to the plateaus above the escarpment. This occupies an area of about 175 square miles, extending to the southwestern corner of the county, where its hills finally merge into the long slope of the northern extension of the Catskills. In the northern part of Knox township there is a region of hills extending northward from the foot of the crest of the great escarpment to Schenectady county, and there are some elevations of the same nature in the central part of New Scotland township.

The great plain.— The great plain extending from the foot of the Helderberg escarpment to the rivers (Hudson and Mohawk) presents wide areas of comparatively smooth surface, having an altitude sloping gradually from 200 feet about Coeymans Junction to 300 feet in the northeastern corner of the county and 400 feet toward Altamont. The streams which traverse this plain are the Normanskill, Vlaumankill, Coeymans creek and Patroon's creek. These streams, and their branches, have cut valleys of various kinds, which are in greater part relatively narrow and steep sided. The plain extends up the Oniskethau and Hannacrois valleys for a considerable distance, and up the Boxenkill to a point two miles above Altamont. About Wemple the higher plain is separated from the Hudson river by a terrace averaging 100 feet above tide, but in the other parts of the region it ends in steep banks bordering the Hudson and Mohawk valleys. These terrace scarps rarely extend to the shore of the river, but rise from a low alluvial plain which occupies a greater or less width in the bottom of the depressions. The city of Albany is built, in greater part, on the slope of this terrace scarp, and along the low narrow terrace at its base. The upper part of the city is on the high plain, at an altitude of from 180 to 240 feet above the river. The surface of the great plain is diversified by a considerable number of hills and ridges rising above its surface. The more conspicuous of these are located mainly north of the latitude of Albany, where they are scattered about irregularly, and give rise to a peculiarly knolly topography. They seldom rise more than fifty feet above the general plain,

and present smooth surfaces, except where they are cut by streams.

The Helderberg escarpment.— The Helderberg escarpment is the most conspicuous topographic feature in Albany county. It rises with great steepness at the western margin of the plain above described, and its precipitous level-crested front is visible for many miles to the east and north. Its greatest development is between Altamont and New Salem, where it finally attains an altitude above the plain of 1200 feet. This elevation is in the eastern face of Countryman hill, opposite New Salem, and is attained in a series of strongly-marked terraces. The escarpment enters Albany county from the westward with less distinctness than it usually presents, owing to a great mass of drift which lies against its face. Its prominence rapidly increases in the central part of Knox township, but its elevation and steepness are variable. To the north it descends to the Boxenkill valley in long slopes surmounted by a more or less distinct precipice at all points. South of Altamont the cliffs increase in height, the slopes rapidly shorten, and the escarpment turns abruptly southward, presenting a mural front 800 feet in height to the eastward. At several points it is recessed, notably at the Indian Ladder, where a magnificent amphitheater has been cut by the little stream which falls over a limestone cliff at the top. The principal features of the escarpment in this vicinity are shown in plate 1.

West of Indian Ladder the escarpment is surmounted by a series of wide plateaus extending far back into the country as shown very plainly in the plate. To the south of Indian Ladder these plateaus and the range of high hills of the third province extend eastward to the edge of the escarpment and a maximum elevation of 1634 feet is attained in Countryman's hill. To the south of New Salem the mass of high hills recede, the terraces expand and the southward dip of the rocks gradually carries the escarpment down to a very moderate degree of prominence. In the central part of New Scotland township its course becomes irregular and it extends to the southward in a series of abrupt offsetting trends to the eastward. In this region there lie in front of the escarpment a series of moderately elevated ridges which here mark the western border of the plain.

South of Feurabush the escarpment increases in altitude, and extends eastward to the margin of the plain of which it thence constitutes the western boundary to the southeastern corner of the county. It here presents its usual characteristics of long walls of limestone cliffs, but the altitude above the plain here averages only about 200 feet. Opposite South Bethlehem the escarpment is broken through by Oniskethau creek and the Spraytkill.

In New Scotland and Coeymans townships the plateaus and terraces above the Helderberg escarpment have a width varying from two to four miles. They present a considerable variety of surface features owing to the erosion to which they have been subjected by the Oniskethau and Hannecrois creeks and their branches. These streams have cut irregular valleys of considerable width across the terraces and isolated a number of abrupt ridges, especially to the southward.

Southwestern townships.— The highly elevated region of the southwestern third of the county presents a great variety of topographic form. Its general character is a high plateau deeply and widely invaded by a complex system of valleys which have reduced the greater part of the area to a series of slopes. A noteworthy feature of the region is the very steep front which it presents to the north and to the east, which rises from 400 to 500 feet abruptly from the upper terrace behind the Helderberg escarpment. This front extends almost due east through the northern part of Berne township and then turns abruptly southward and extends along the eastern front of the Helderberg mountains to Clarksville. South from Clarksville, in Bennett, Copeland and Blodgett hills, it offsets to the eastward in a series of ridges very abruptly terminated northward. A reference to the topographic base map accompanying this report will, I believe, be the most satisfactory means of forming a conception of the nature of these curious offsets.

The hills of this southwestern region increase in altitude to the north and west from about 1000 feet in Coeymans township to 1700 feet in the northern part of the Helderberg mountain, and over 2000 feet west of Rensselaerville. To the north the region is deeply invaded by the Switzkill, which has cut a deep, steep-sided valley extending far southward. From the west it is

invaded by the Little Schoharie creek, from the south by several important branches of the Catskill, and from the southeast by Hannecrois creek. These drainage systems quite widely overlap each other in the central part of the region, and the main stems of their upper waters are in greater part separated by divides which are considerably lower than the adjacent hills. The most noteworthy of these low divides is north of Rensselaerville, where the elevation of the divide between the Switzkill and Ten-Mile creek is approximately 1480 feet, while the surrounding hills have an altitude of about 300 feet more.

The divide between Little Schoharie creek and Ten-Mile creek is at about 1700 feet above tide, which is considerably below the level of the adjacent hills. This feature of low divides is general throughout the region, as reference to the topographic base of the geologic map will show.

Along the steep eastern front of the region there is considerable invasion by small streams, mainly by the head-waters of Oniskethau creek, which cuts across the ridge of the Helderberg mountain, and by some branches which head behind Bennett, Copeland and Blodgett hills.

A very large part of the region presents a terraced surface due to alternations of hard and soft beds.

GENERAL STRUCTURAL RELATIONS.

The general geologic structure of Albany county is indicated by the section in figure 1.

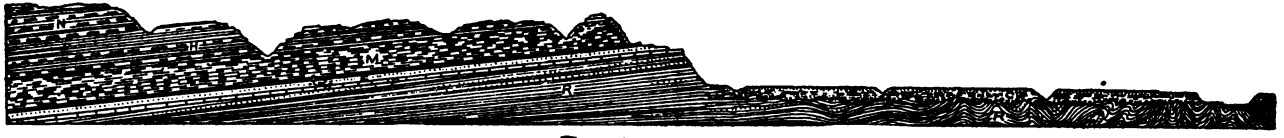

Fig. 1.

FIG. 1.—Section from southwest to northeast through Albany county exhibiting the general relations. N., Oneonta formation; H., Hamilton flag series; M., Hamilton shales; O., Onondaga limestones; E., Esopus slates, Oriskany sandstone, etc.; P., Lower limestones of the Helderberg series; R., Hudson river formation; C., Clay and sands on glacial drift. Horizontal scale, four miles to one inch. Vertical scale and rate dip greatly exaggerated.

This section shows a great succession of beds of various rocks dipping gently to the southwestward, excepting in the vicinity of the Hudson where there is much disturbance. The wide plain of sand and clay extending west from the Hudson river is underlaid at a greater or less depth by the members of the Hudson river formation. The great cliffs of the Helderberg escarpment are due to the overlying Helderberg limestones, notably a medial member of the series, and the terraces and plateaus beyond, to alternations of limestones, shales and sandstones. A great series of overlying shales and flags constitute the high region which rises abruptly to the south and west and extends to the foot hills of the Catskills. In this wide area of highlands, higher beds come in succession to the southwestward.

There is considerable variation in the relations of the terraces and plateaus behind the crest of the Helderberg escarpment and in the nature of this escarpment, but they are all clearly shown on the geologic map and described in the following pages. In the northwestern corner of the county the Hudson river members of the series rise into high hills which extend to the Helderberg escarpment southward, a feature which is general for many miles west of Albany county but ends abruptly in the northern part of the Helderberg mountain.

In the southeastern corner of the county the Helderberg and overlying formations extend into the disturbed belt adjoining the Hudson river, and are flexed and faulted to a considerable degree.

STRATIGRAPHY.

The stratigraphy of Albany county has been comparatively well known for over half a century. In 1820 Prof. Eaton* published a report in which the more prominent features were outlined, and the later studies by Mather† and Hall‡ of the Geological Survey, have afforded knowledge as to the character, age, palæontology and relations of the principal formations.

In the following descriptions I shall give a resumé of the principal characters of the formations extended somewhat by new information regarding local features and distribution.

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*Amos Eaton and T. R. Beck. A geological survey of the county of Albany, 56 pages, 8vo Albany, 1820.

†Geology of New York. Part I. Comprising the geology of the First Geological District. Albany, 1843.

‡Palæontology of New York, and many papers on New York geology.

The rocks in Albany county are the Hudson river slates and sandstones, and members of the upper Silurian and Devonian from the Salina to the Oneonta. They are as follows:

	Thickness. Feet.
Oneonta, red shales and flaggy sandstones	1000
Hamilton flags and shales	700
Hamilton black shales	600
Onondaga limestone	70
Schoharie grit	6
Esopus shales	100
Oriskany sandstone	4
Becraft limestone	15
Shaly limestone	100
Pentamerus limestone	65
Tentaculite limestone	30
Salina waterlime	4
Hudson river shales and sandstone	3500

There are also wide areas of sand and clay and many deposits of glacial drift. The Oneida, Medina, Clinton and Niagara formations are lacking, possibly the Niagara formation exists at some points in the base of the Helderberg escarpment under the drift and talus.

Oneonta formation. — This formation has not before been differentiated in Albany county, but I have traced it continuously from the typical region eastward and find that it is extensively developed. It consists of a series of flaggy sandstones with intercalations of red shales which cover the elevated regions of the southwestern corner of the county in Rensselaerville and Westerlo townships. It is cut through by the valley of Ten-Mile creek, which separates the high regions west and south of Rensselaerville. The red shales are a conspicuous feature of the formation and are extensively exposed throughout its area. They constitute beds of from one to thirty feet in thickness, intercalated at irregular intervals among dark-gray, flaggy sandstones. There are also in the formation, beds of red sandstone and thin beds of dark gray or black shales, but they are of infrequent occurrence and of no great thickness. The beds of red shale appear to be continuous over wide areas, but in

some cases, at least, they thin out and give place to slabby sandstones. Their materials do not merge into those of the enclosing members, and they appear to be separated, in most cases, by slight local unconformities. The red sandstones are hard, moderately coarse-grained, thick-bedded quartzitic rocks, and it is thought that they do not represent a definite horizon. The region occupied by the Oneonta formation in Albany county is much obscured by accumulations of drift, which render precise determination of stratigraphy a matter of great difficulty. There are, besides, rapid changes in the character of the beds, which give rise to considerable dissimilarity in sections of the same series made at any great distance apart. From the northeastward the first exposures of the Oneonta formation are near the summit of the high ridge east of Rensselaerville, where the red shales outcrop along the road and in the adjacent fields over a narrow belt. This belt widens to the southward and covers all of the high region along the Westerlo-Rensselaerville boundary. Owing to very heavy drift cover in this region, exposures are neither frequent nor extensive, but there are many small showings of the red shales and flaggy sandstones in various stream and road cuts.

In the highlands northwest of Rensselaerville the Oneonta formation thickens rapidly and is spread out over a wide area extending far into Schoharie county. The red shales and associated beds are seen in a limited area north of the headwaters of the Little Schoharie creek, the valley of which cuts through to the underlying formations. In the southern part of Rensselaerville township the formation is very extensively exposed in the deep valleys and along the hill slopes which characterize this region. Above Preston Hollow the Catskill creek cuts through two members, which belong apparently to the underlying series, but about Preston Hollow and below, the banks exhibit the red shales and associated beds of the typical Oneonta, although not far above its base. The surrounding hills rise to an altitude averaging about 1000 feet above the bottom of the Catskill creek valley, and consist of the characteristic succession of red shales and gray flaggy sandstones. Exposures are abundant in this region, although there are areas of drift which hide the formation at some localities.

The maximum thickness of the Oneonta formation exposed in Albany county is about 1000 feet, but there are higher beds of the formation to the southward in the northern front of the Catskills. In mapping the Oneonta formation in Albany county I have assumed that its base was at the bottom of the lowest red shale member, because this was the only distinguishing feature that I could use as a guide. Probably this horizon will prove, on detailed examination, to be somewhat variable, but I believe not with very wide limits.

Hamilton flags and shales.— Underlying the Oneonta formation there is a great series of thin-bedded sandstones of various kinds, with intercalated beds of dark-colored shales The flaggy members are the more prominent because they give rise to conspicuous outcrops and to a characteristically terraced topography. The shales constitute about an equal proportion of the series, and give rise to the slopes between the terraces. The flags are dark-gray, moderately fine-grained sandstones varying in thickness from one-half inch to three inches, and in greater part separating readily along their bedding planes. They have been quarried to a considerable extent for the market, and are highly esteemed for flagging. The thickness of the beds of flags is exceedingly variable, ten to fifteen feet is frequent, but there are beds which have much less thickness. It is found that in part some of the flag beds give place to black shales and they also vary considerably in thickness of bedding, in texture and in color in the same bed. The intercalated shales are in greater part moderately hard, dark in color, and have a thickness ranging from fifteen feet to a few inches. No definite stratigraphy was made out in the flagstone belt, owing to considerable obscurity of outcrops by drift and the frequent changes in the character of the deposits. The amount of workable flagstone in the series is very great, but on account of the distance from adequate means of transportation and the consequent great expense of hauling, it is now practicable to work only those beds which yield stone at the very least cost. Owing to the variability in the character of the flags, and to the presence of large amounts of waste material which has to be stripped, there are many areas underlaid by excellent flagstone which cannot be profitably worked. This is particularly the case on steep slopes, where the flags dip into the

hill. The beds of flags are not at any definite horizon, although the greater amount of flag which has been worked is from beds about 250 feet above the base of the series. The principal quarries are between Rensselaerville and South Berne, at Reidsville and at Dormansville. There are many small quarries scattered about at various localities. The quarries between Rensselaerville and South Berne are in a bed about twelve feet thick, which is relatively uniform in character throughout, and has yielded a valuable product. The Reidsville quarries have been worked in several beds, constituting a local series, about twenty-five feet thick. The Dormansville quarries are in a bed about ten feet thick, which yielded a very large amount of excellent flagging. The region occupied by the flag series is deeply trenched by the Switzkill, which cuts through into the underlying shales. It extends southward into Greene county and the deep valley of Ten Mile run and are finely exposed at the falls at Rensselaerville and end in the gorge above. They are widely removed in the region adjacent to the Hannacrois creek, but there are outliers along the higher summits of the Helderberg mountains, in the high area west of Countryman hill, and in the higher summits of Koong and Blodgett hills, which all appear to belong to this series. The basal line of the formation has been drawn at the bottom of the lowest heavy bed of flags which appears to be a relatively constant horizon over a wide area, although its stratigraphic position may vary somewhat. The thickness of the series is about 700 feet. It dips south-southwest in Berne township, and to the southwest in Westerlo township. There are local variations in the direction and amount of dip but they were not studied in detail.

The lower portion of the formation is sparingly fossiliferous, particularly some of the softer thinner flags, which yield a Hamilton group fauna. The upper beds of the series may extend above the limits of the Hamilton group of western New York, but I have at present no definite evidence on this point.

The Hamilton black shales.— This formation comprises 600 feet of argillaceous deposits lying between the flagstone series and the Onondaga limestone. It constitutes the steep northern and eastern slopes south and west of the Helderberg

escarpment, and is a surface formation over the wide area in western Coeymans township drained by Hannecrois creek, deeply excavated by the Switzkill, up which it extends southward nearly to South Berne, and it occupies a wide area of moderately high land extending north from East Berne. It consists in greater part of shales, hard above and softer below, with occasional thin, intercalated beds of flaggy sandstones among its upper members. Its basal beds are in some places so dark that they have been mistaken for coal, and many attempts have been made to work them for coal. Their dark tint is due to the presence of a very large amount of carbonaceous material, which in some cases will burn for a few minutes when the shale is put in the fire. There are, however, as every geologist knows, no beds of coal in this formation, and all attempts to obtain coal therefrom will be futile. The shales of this formation are abundantly fossiliferous in certain beds at various horizons, and, as well known, contain the fauna of the lower Hamilton group.

Onondaga limestone.— This formation gives rise to a terrace of greater or less width extending along the foot of the steep slopes of the Hamilton shales. In the northeastern face of the Helderberg mountain its outcrop is very narrow, in some places not over 100 feet. Westward, it widens to a mile and a half about Thompson's lake, then is contracted again by the northern extension of the Hamilton formation north from East Berne, west from which it widens to nearly three miles in the long slopes northwest of Berne. It is spread out over a considerable width about Clarksville and Oniskethau creek. At the north end of Copeland and Blodgett hills it is narrowed to 200 yards, constituting a very distinct shelf, on the relatively smooth surface of which the road passes for several miles. A mile east of Clarksville there is a small outlier of the formation, which is a very unusual feature. There is also a small outlying area on top of the ridge three miles south by west of South Bethlehem.

The surface of the formation is much obscured by drift in some districts, notably in the wide area north of Peoria where outcrops are exceedingly rare on this account.

The formation consists of a light blue gray, sub-crystalline, tough, massively-bedded, pure limestone containing lenses of chert in courses and irregularly disseminated. In the bed of a

PLATE 2.

Lower Members of the Onondaga Limestone on Oniskethau Creek at Clarksville. Looking Southwest.

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small creek a few rods west of Peoria (West Berne), the upper beds are seen to consist of a very dark, coarse, crystalline limestone, quite closely resembling black marble in appearance. It is apparently of local occurrence, for I have not observed it elsewhere. The occurrence of chert in the formation is very irregular, but it is in largest amount in the lower beds. In some localities it is almost altogether absent, but this is unusual. Thin intercalations of shale occur at some localities, but they, also, are exceptional features. The limestones are fossiliferous to a variable extent. The principal fossils are comprised in beds consisting largely of corals which occur in some places. The most notable outcrops of beds of this character are along the road a half mile northwest of Thompson's lake, where the corals are so numerous that the bed may properly be designated a fossil coral reef. In the bed of the Foxkill, at Peoria, corals also occur in abundance, constituting a large portion of the beds of limestone here exposed. There also occur other fossils than corals, and these are present in greater or less amount at almost every locality, although they are not conspicuous. One of the finest exposures of the formation in the county is in the cliffs along Oniskethau creek, at Clarksville. In plate 2 there is given a view of the general appearance of a portion of this exposure.

The occurrence of many sinks in the Onondaga limestone is a noteworthy feature. These are depressions in which the drainage of a greater or less area disappears into fissures or caves in the limestone. Thompson's lake is the most notable of these, and there are several smaller sinks southeast of Thompson's lake and another at a point two miles north-northeast of Berne. In the limestone shelf along the eastern face of the Helderberg mountain, Bennett, Copeland and Blodgett hills, there are many small sinks at or near the margin of the Hamilton shale, which are a conspicuous and characteristic feature of this formation.

Schoharie grit.— This formation has not been separately represented on the map owing to its restricted occurrence. It is well characterized at Clarksville and for several miles in that vicinity, but elsewhere in Albany county it appears to be absent. It a very impure limestone, which weathers at the surface to a

dark buff, spongy, sandrock, containing an abundance of characteristic fossils. It merges into Onondaga limestone above, but is quite sharply separated from the underlying Esopus shales. The greatest thickness observed was six feet in an exposure along the road on the slope three-fourths of a mile south of Callanan's Corners. At Clarksville the amount is considerably less, and along the road at the base of Countryman hill it is apparently not over a few inches. In the intervals between these three exposures, I found no outcrops. To the north and west there are a few exposures of the base of the Onondaga limestone, in which the Schoharie grit is seen to be absent, and this appears to be the case in the southeastern corner of the county, although critical exposures were not found.

Cauda-galli grit = Esopus slates.--This formation consists of dark-colored, sandy shales, which, to the southward, have a pronounced slaty cleavage. In the Helderberg mountain and westward these shales give rise to the slope extending from the terrace of Onondaga limestone above to the terrace of Oriskany sandstone below, a feature which is very characteristic. In the flexed region south of South Bethlehem the formation is spread out over an area of considerable width, in which it gives rise to very sharp ridges with abrupt slopes and barren aspect. The sharpness of these ridges is due in the main to increased hardness of the formation and the development of slaty cleavage, which characterizes the formation from this district southward. In color the shales are in greater part very dark gray, which weathers somewhat lighter on long exposure. The finest exposures are in the ridges south of South Bethlehem, in the gorge of the Oniskethau at Clarksville and below, at several points along the eastern face of the Helderberg mountain, and at intervals westward by Knox. It extends several miles southward in the north fork of the Foxkill, being finely exhibited in a short gorge a mile due north of Berne and apparently extending to within a short distance of that village. The thickness of the formation averages about 100 feet in Albany county. The formation exhibits on its bedding planes, wherever these are exposed, impressions of a fucoid known as *Spirophyton caudi-galli*, or the "cock-tail fucoid." These impressions are most distinct where the beds are slightly quartzitic, a

feature not unusual near the upper part of the formation. The finest exposures that I have seen of this stratum are at Clarksville in a small inlaying area exposed in the stream cut just south of the center of the village.

Oriskany sandstone.— This is a very thin bed of hard sandstone or quartzite which is continuous over a wide area. Owing to its hardness it usually gives rise to an outcrop of considerable width constituting a well-defined shelf, at the base of the slopes of Esopus shale. This shelf bears in some parts of the area masses of glacial drift and the formation is completely hidden by this material near the western margin of the county and at several points in the Oniskethau valley. Between Knox and Indian Ladder the formation affords a hard, even bed for the roads for considerable distances, and its exposures along these roads are very characteristic. For several miles south from Callanan's Corners the formation appears to be absent, as several exposures were examined in which the Esopus shales appeared to lie directly on the Becraft limestone. It comes in again west of Coeymans Junction, where it is exposed at several points at the base of the easternmost ridge of Esopus shales. The formation is in greater part calcareous, but the amount of lime which it contains is variable. Usually there are beds which are very calcareous and weather to a porous buff sandrock filled with characteristic casts of the fossils; and these are conspicuous in nearly every exposure. The thickness varies from one to four feet and averages about three feet over the greater part of the area.

Becraft limestone.—This is the uppermost member of the Helderberg limestones. It is a light-colored, coarsely semi-crystalline rock in thick beds. It is highly fossiliferous, consisting in considerable part of replacements of fossils. The most conspicuous of these are the cups or pelves of a crinoid, having in greater part a diameter of from one to two inches. The white calcite by which these remains are now represented contrasts strongly with the light bluish-gray of the containing limestone and are a distinguishing feature throughout. Its thickness averages about fifteen feet, but at some points it appears to be slightly less. It usually gives rise to a low cliff capped by the Oriskany sandstone; its finest exposures are in the vicinity of Knox, but it is also frequently

seen in the Helderberg mountain and in the vicinity of Clarksville. Between Oniskethau and Callanan's Corners it is in greater part covered by drift. It comes out again in the creek bed just south of Callanan's Corners and at various other points in the vicinity. South of South Bethlehem it extends over a considerable area in the flexures which traverse that district, particularly along the base of the steep ridges of Esopus shales. Its relations in this region are shown on the section in plate 5.

Shaly limestone.—The Becraft limestones are underlaid by a series of thin-bedded, very impure, highly fossiliferous limestones, containing many shaly intercalations, and varying in color from gray to gray brown. As is the case with the Esopus shales, they are regularly bedded westward, but in the flexures south of South Bethlehem they are traversed by more or less slaty cleavage, and become considerably harder. In the Helderberg mountains and westward they constitute the slopes or gently rolling plateaus above the Pentamerus ledges, but to the southward they give rise to sharp ridges covered with rugged ledges, in some cases closely resembling the lighter-colored outcrops of Esopus shales. In the high ridge between Clarksville and Stony Hill there are several outliers of the formation. The thickness of the Shaly limestone averages 100 feet throughout.

Pentamerus limestone.—This is the most conspicuous member of the Helderberg formation, for its outcrop is marked by extended lines of prominent cliffs, in most cases surmounting long slopes of the underlying formations. In the few valleys by which it is crossed it gives rise to falls. The formation consists of hard, very massively-bedded limestone of bluish-gray color, weathering to a somewhat lighter tint. The beds are traversed by vertical jointing, and this character, together with the presence of softer underlying beds, gives rise to the cliffs which characterize its outcrop. Besides the thick regular bedding there is also an irregular sub-bedding into flat, interlocking lenses and corrugations, the outlines of which are brought out by weathering. Occasional shale partings occur, and also nodules and thin lenses of chert. The thickness averages sixty-five feet throughout Albany county. Owing to its hardness the formation is almost everywhere exposed, but the finest exhibition is in the northern and eastern face of the Helderberg mountains, where it presents the appearance represented in plate 1.

PLATE 3.

Cliffs of *Pentamerus* and Tentaculite Limestone at the Indian Ladder, Albany County, N. Y. Looking Southwest.

Not to be taken away

In Knox township the cliffs of Pentamerus limestone vary considerably in elevation, but they are continuous throughout. At several points in the western part of the township there are heavy masses of drift piled against the cliffs, but they are not entirely buried. At the Indian Ladder the cliffs expose the entire thickness of the formation, together with the underlying beds. A view of this feature is given in plate 3.

In the ridges east of Clarksville the formation occupies an area of considerable width along the crests, and extending down their western slope to the Oniskethau creek. The cliffs trend to the eastward along portions of their course in this region, and the escarpments presented northward are heavily flanked by drift. From Feurabush southward the Pentamerus cliff has considerable prominence, except for a short distance west of South Bethlehem, where it is crossed by the low gap between Oniskethau and Sprayt creeks. South of here the line of cliffs is continuous to the gap cut by the Hannacrois creek in Greene county.

Tentaculite limestones — These are thin-bedded, dark-blue limestones lying below the Pentamerus beds and usually outcropping in the base of the Helderberg escarpment or lying beneath its talus. The strata vary in thickness from an inch to a foot, in greater part, but two or three inches is the general average. There are occasional intercalations of shaly beds. In the upper members, in most localities there is a thin bedding or ribboning of alternating lighter and darker tints, which is the "ribbon limestone" of some writers. Toward the base of the series there is usually a more massive bed containing *Stromatopora*, but the member is not conspicuous in Albany county in its typical development.* The Tentaculite beds have a thickness of about thirty feet along the eastern face of the Helderberg mountain, and this appears to be the average thickness throughout.

The beds are frequently exposed at intervals along the Helderberg escarpment. They outcrop at several points southwest and south of Altamont, at the Indian Ladder, southwest of New

*This Stromatopora bed is excellently exposed on the Albany and Schoharie plank-road beyond Altamont; also about two miles west of the road from Albany to Clarksville on the land of Mr. Merkel, and on the same road two miles northeast of Clarksville. There is also a good exposure on the slope of the hill at Coeymans Junction, both on the roadside and in an extensive quarry. Most of these exposures show that the bed lies but a few feet below the Pentamerus limestone.—H.

Salem, and about South Bethlehem. A mile and a half southwest of South Bethlehem they are brought up by a small anticlinal and exposed over an oblong area surrounded by the Pentamerus beds. They are extensively exposed in the road-metal quarry at South Bethlehem surmounted by the lower beds of the Pentamerus limestone, as shown in plate 4.

Salina waterlime.— This formation is represented in Albany county by a few feet of waterlime beds, which may not be continuous throughout. Only two distinctive exposures were found: one at the Indian Ladder, and the other in the floor of the quarry at South Bethlehem. The thickness in both cases is about four feet. The beds are impure, magnesian limestones, in three or four layers with some shaly intercalations. The upper surface of the series in the quarry is characterized by a reticulation of sun cracks, which are usually distinctive of this horizon. There is apparently no cement included, so far as I could ascertain from these two exposures.

The unconformity.—At the base of the Salina formation there is an unconformity representing the early part of upper Silurian times. It is an unconformity which is general in eastern New York but appears to give place to a continuous succession in the western part of the State and to the southward from central Pennsylvania. In Albany county there was apparently no deposition of Niagara, Clinton, Medina or Oneida formations, but it is possible that they were deposited in attenuated form and then removed by erosion. The principal feature of the epoch was a general uplift of the Hudson river sediments without material flexing westward but with considerable disturbance in the vicinity of the Hudson river valley and eastward.

In the Helderberg mountains and westward the Salina and Helderberg limestones lie on the Hudson river formation without appreciable unconformity in dip. To the southeastward, in the region where the Hudson river and overlying formations are flexed, there is a prominent unconformity in dip. There are excellent exposures of the contact at Indian Ladder, at a point a mile due south of New Salem, on Sprayt creek, at the road metal quarry south of South Bethlehem and near the road a mile southwest of Coeymans Junction.

PLATE 4.

Tentaculite Beds with Lower Portion of the Pentamerus Limestone, Road-metal Quarry, South Bethlehem. Looking South.

The Hudson river formation.— The Hudson river formation consists of dark shales with interbedded, very fine-grained, massively-bedded sandstones, which are frequent in the upper members but thinner and less frequent below. In the lowest beds there are intercalations of black carbonaceous slates containing a well-known graptolite fauna.

A greater part of the wide area occupied by this formation is overlaid by Champlain deposits, and it constitutes the surface only in the hills west of Altamont, along the lower slopes of the Helderberg escarpment and along or near the Hudson and Mohawk rivers. There are fine exposures above Altamont where the Boxen Kill has cut a ravine through the formation; and there are extensive outcrops in "gulfs" in the Indian Ladder region. In the banks of the Mohawk there are frequent exposures, notably at the great falls at Cohoes. Along and near the Hudson there are scattered outcrops of which the most extensive are on the lower Norman's Kill at Kenwood and on the West Shore railway along the scarp of the second terraces from "The Abbey" to Wemple. Within the area of the great plain of Champlain deposits exposures are rare, for the streams seldom cut through to the slates. The exposures along the Spraytkill, southwest of South Bethlehem, are the best that I observed. They extend from the fault to the vicinity of the road-metal quarry.

The graptolitic beds are exposed at Kenwood and along the railroad a short distance south of "The Abbey." They appear to constitute the lowest members in Albany county, but the structure in this region is so complicated by intense folding, accompanied by crushing and faulting, that the relations were not apparent. The black graptolitic slates, gray slates and shales and sandstones are intermingled in the most complex manner and extended observations will be necessary to unravel the relations.

The thickness of the Hudson river formation is not less than 3480 feet, at least in the region near Altamont. This estimate is based on the record of the gas wells bored near Altamont in 1886, which, according to Ashburner,* penetrated 2880 feet to the Trenton limestone. I find that there are about 600 feet more

* Petroleum and natural gas in New York State; Am. Inst. Mining Engineers. Trans., vol. 16, pp. 906-953, plates. 1889.

of the formation up to the Helderberg beds in the slope southward, which gives a total of the thickness of 3480 feet.

STRUCTURE.

The general structure of Albany county is represented in figure 1. In the following statements an account will be given of the exceptional features of the structure.

The monoclinal region is relatively uniform in relations. There are many slight local variations in the amount and direction of dip, but these are more apparent in their general effect on the distribution of formations than in local outcrops. The two sections in the following figure represent the principal features in the vicinity of the Helderberg escarpment to the northwestward.

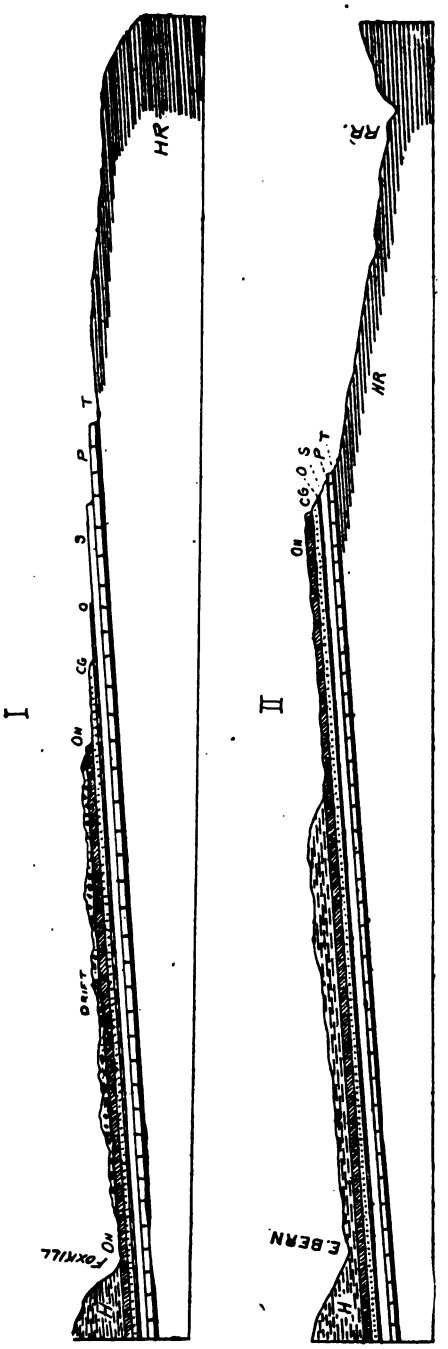


FIG. 2 represents the Helderberg escarpment and vicinity in the northwestern part of Albany county; H., Hamilton shales; On., Onondaga limestone; C.G., Esopus shales; O., Oriskany sandstone; S., Becraft and Shaly limestones; P., Pentamerus limestones; T., Tentaculite and Salina beds; H.R., Hudson river formation.

In section I the amount of dip appears to be not over 100 feet to a mile Here the Onondaga limestone is bared over a wide area, and the underlying formations outcrop in succession northward in broad terraces. They are, however, heavily drift covered and there are too few outcrops on which to base a satisfactory determination of structure. In section II, the dip is about the same or slightly less and the Hamilton shales are seen extending to within a mile of the Helderberg escarpment, with the underlying formations occupying narrow belts in the slopes below. To the eastward about Thompson's lake and Indian Ladder the dip is reduced to an amount not over thirty-five feet per mile, but there is some evidence that it is more variable in this section than it is to the westward. The following figure is along the eastern face of the Helderberg mountains and exhibits the structure of this great escarpment, which is such a conspicuous feature in Albany county. In this vicinity the southerly dip gradually changes to the southwestward and decreases in amount.

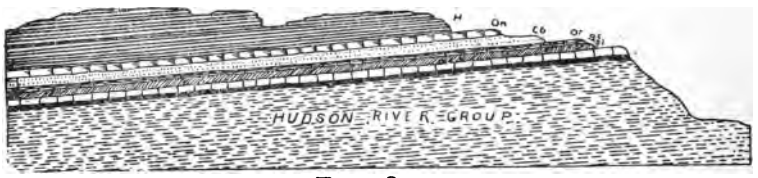


Fig. 3

FIG. 3.—Section along the eastern face of Helderberg mountains, in the vicinity of New Salem. Scales: Vertical, 1600 feet to one inch; horizontal, 4000 feet to one inch; H., Hamilton; On., Onondaga limestone; CG, Esopus shales; Or., Oriskany; Sc., Becraft limestone; Sl., Shaly limestone; P., Pentamerus limestone; T., Tentaculite beds and Salina waterlime. Looking west.

The succession of rocks is superbly exposed in the eastern face of this great escarpment as a series of terraces, from the Hamilton at the top, to the long slopes of Hudson river shales and sandstones below; the principal terrace scarps being marked by the Onondaga limestone, Oriskany sandstone, and Pentamerus limestone with adjoining formations in the intervening slopes. The dip averages 112 feet per mile and south ten degrees west in direction. This carries the outcropping edges of the formation gradually downward along the face of the mountain, from an altitude of 1100 feet above tide south of Altamont to about 1000 at Indian Ladder and 660 feet a mile south of New Salem. To the

southward about Clarksville, the rate of dip gradually decreases to sixty feet per mile, and its direction changes to due west. As the formations of the Helderberg mountains are brought down to the general country level, they extend to the east and south into a flexed region. The first features noticeable are a series of gentle undulations which broaden the outcrop areas of the limestones and indent their edges into a series of *en echelon* offsets. These undulations enter the Helderberg area in succession from

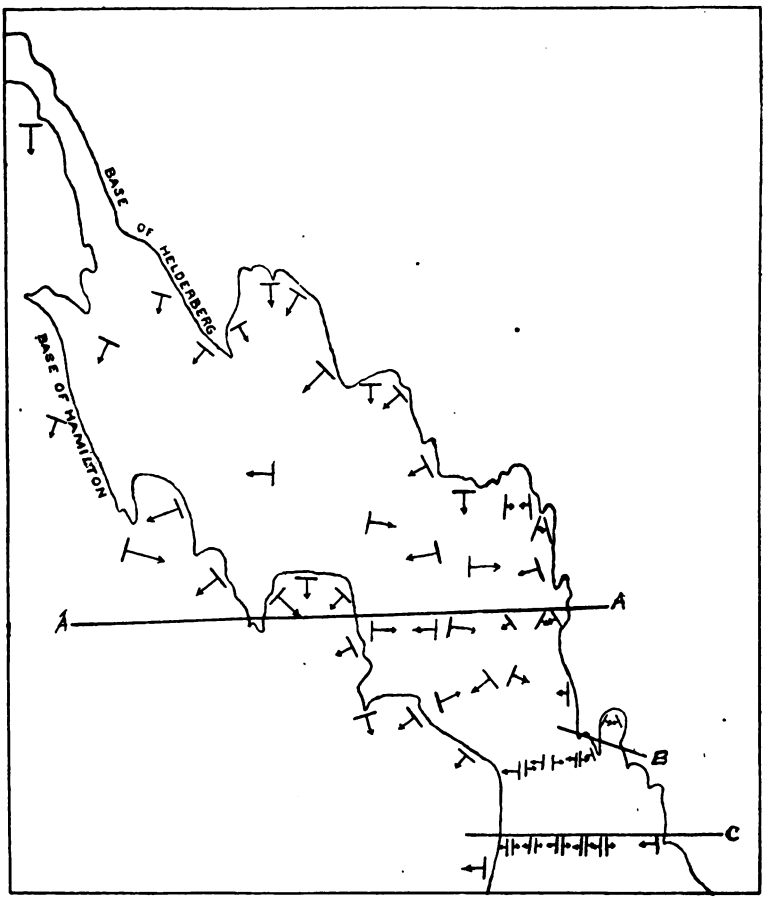


Fig. 4

FIG. 4.—Diagram of a portion of Albany county to illustrate the undulations at the edge of the folded region, from New Salem southward. Scale, two miles to one inch. The length of the stems of the dip marks is inversely proportional to the amount of dip. A–A. Section given in *figure 5*. *B*. Section in figure 6. C. Northern section on plate 5.

west to east, as it extends southward, along axes striking south ten degrees west, approximately, and pitching slightly in the same direction, which is diagonal to the general inclination of the monocline. In figures 4 and 5 I have attempted to illustrate the nature of these features in the limestone area, for they are an interesting example of the beginning of the series of flexures, and they explain the singular distribution of the Helderberg rocks in this portion of Albany county.

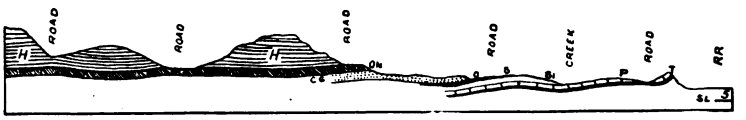


Fig 5

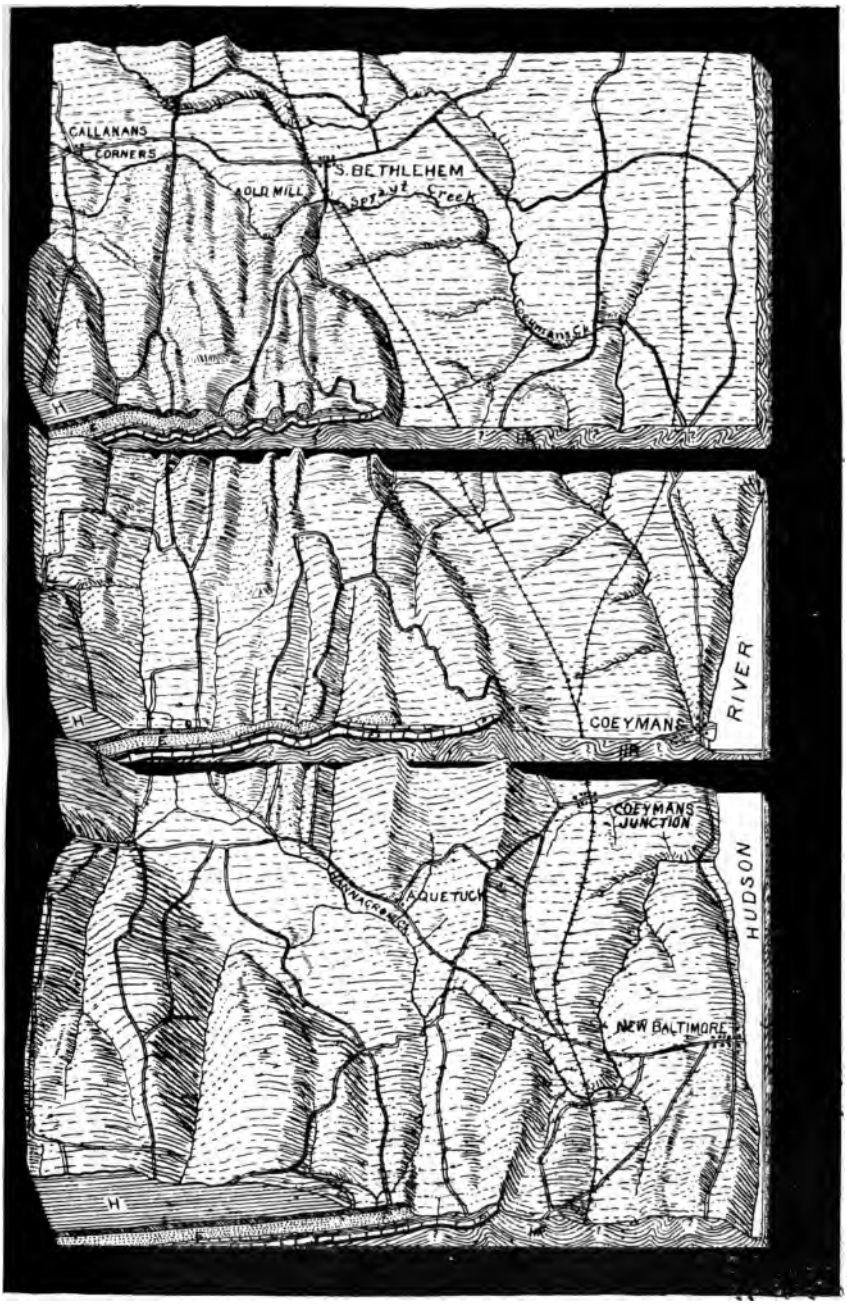
FIG. 5.—Cross section on line A-A in figure 4. From north of South Bethlehem through Copeland hill. Vertical scale, two and one-half times the horizontal scale. H., Hamilton; On., Onondaga limestone; CG., Esopus shales; O., Oriskany: S., Becraft limestone; Sl, Shaly limestone; P., Pentamerus limestone; T, Tentaculite beds and Salina waterlime; SL., Position of sea level. Looking north.

It will be seen in these figures that the undulations increase in steepness to the eastward and finally become a succession of steep parallel folds which are of true Appalachian type.

In plate 5 there is shown the structure of the flexed region in the southeastern corner of the county and for a couple of miles southward.

In this plate there should be noticed the distinct topographical characteristics of the several formations of the Helderberg and overlying formations The steep slope or scarp of the Pentamerus bed is sharply defined except at the Hannacrois creek, where it is broken across; but it gives rise to falls of considerable amount in the creek, with a deep gorge for some distance below. The Esopus shales constitute sharp ridges and the Onondaga limestone is marked by a well-defined shelf, which expands to great width in the Hannacrois valley. The Hamilton shales rise abruptly into high, irregular hills of typical character. In the northern section on plate 5 the flexures are steep and involve the Helderberg and overlying rocks over a belt of considerable width. The steepness of the cliffs decreases southward for some distance, and near the second section there is a succession of

PLATE 5.



Stereogramic Map and Sections of the Southwestern Part of Albany County. Scale, One and Three-tenths Miles to One Inch; Vertical Scale Considerably Enlarged.

H. Hamilton shales; O. Onondaga limestone; E. Esopus slate and Oriskany sandstone; P. Pentamerus *limestone underlaid by* Tentaculite and water-lime beds and overlaid by Shaly and Becraft limestone; *R. Hudson river formation.*

Mau

gentle corrugations in a west-dipping monocline, which pitches slightly to the southward. It bears a wide area of Esopus shales, which dip beneath the Onondaga limestone to the west and south. The corrugations flatten southward and extend the Onondaga limestone over a wide area in the Hannacrois valley, also giving rise to the eastward extension of the Hamilton hills in this region.

One of the most noteworthy details of structure in southern Albany county is an overthrust of small amount, but with most interesting features. It is among the gentle flexures near the northern edge of the disturbed area in the Helderberg rocks. Its general relations are represented in the following section:

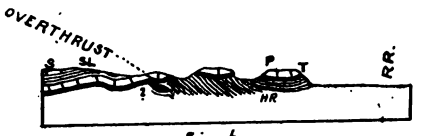


Fig. 6

FIG. 6.—Cross-section southwest of South Bethlehem, showing relations of the overthrust. S., Becraft limestone; SL., Shaly limestone; P., Pentamerus limestone; T., Tentaculite limestone and Salina waterlime; HR., Hudson river formation. Looking north-northeast. Horizontal scale, one mile to one inch. Vertical scale exaggerated two and one-half times. This section is at 5A. on figure 4.

The characteristics of this overthrust are an "underturned" flexure in the thin-bedded underlying limestones, also involving the soft slate of the Hudson river formation, and a fault which offsets the flexure and traverses the hard, massive overlying beds of Pentamerus limestone. The overthrust is exposed only on Sprayt creek, which it crosses at an old mill about three-quarters of a mile west-southwest of the village. Its trend is north and south, but it does not appear to extend for any great distance. The principal features of the exposure at the mill are shown in plate 6, in which the enclosed wedge of slate is shown in the lower left-hand corner, the flat arch of the enclosing limestones in the middle of the view, mainly far to the right. The massive overlying series is the Pentamerus bed.

The relations at the mill and their interpretation are further illustrated in the following figures, in which the features above

the broken-line portion of the sections are exposed in the bed and banks of the creek.

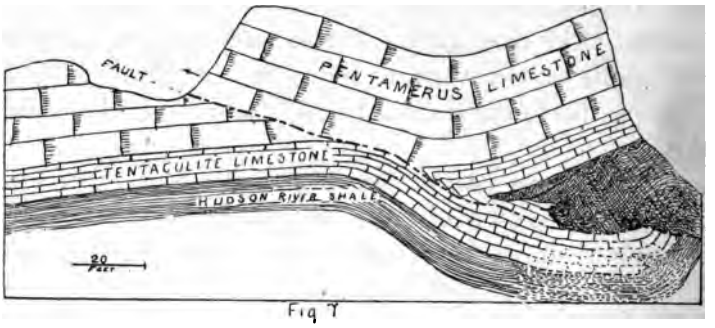


FIG. 7.— Cross-section of overthrust west of South Bethlehem, Albany county. Exposure on south bank of Sprayt creek. Looking north. (Reversed.)

I discovered these overthrusts in the autumn of 1892 and sent a brief account of their relations to the Geological Society of America.* In 1893 I again visited the locality and on careful re-examination, under much more favorable conditions, found that the features were somewhat more complicated than I had first supposed.

It is unfortunate that the exposures are not more complete, but sufficient is seen, I believe, to substantiate the interpretation given in the figure. Only the upper portion of the "underturned" fold is exposed in the limestone, but the greater part of the fault plane is visible on the south bank of the creek above the dam. The enfolded slate is seen to be excessively crumpled and its original bedding planes obliterated, but the lower limestones bend over the arch with but little fracture. There has been considerable slipping along the contact of the slate, and the portion of the limestone which is folded under is considerably broken and contorted. At several points, as shown in the figure, fragments of the limestones have been torn off and are more or less surrounded by the slate.

In the north bank of the creek, under the mill, the exposure is less extensive, but the general relations are similar to those on the south side. The principal features in this exposure are shown in the following figure.

* Published in the Bulletin, vol. 4, pp. 436-439.

OVERTHRUST ON SOUTH BANK OF SPRAYT CREEK, OPPOSITE THE OLD MILL, ONE MILE WEST OF SOUTH BETHLEHEM.

The mechanism of the overthrust is, I think, not difficult to understand, and I have represented the hypothesis of its development in the diagrams in the above figure, I, being the first stage, II, the second stage, and the present conditions the third stage.

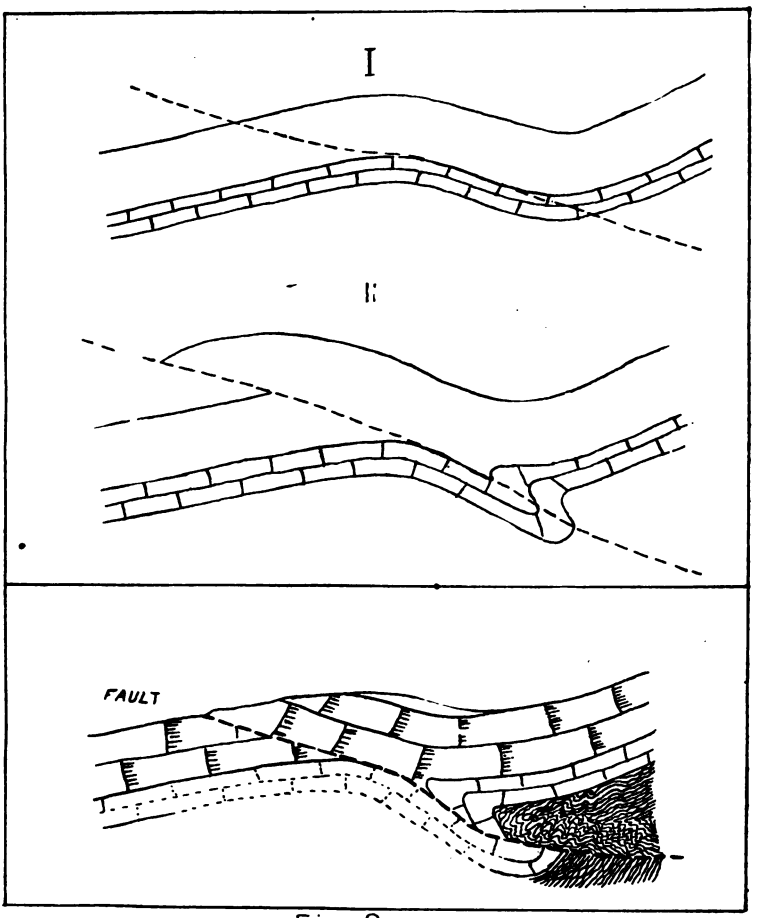


Fig. 8

FIG. 8.— Overthrust on Sprayt creek. A, cross-section on north bank. Looking north. I and II, hypothetical section to illustrate stages of development of the overthrust.

The broken line on I indicates the plane of weakness, the arrow the direction of thrust. The fault, sheared diagonally through the massive beds of Pentamerus limestone but the softer, thin-bedded, underlying limestones in moving forward with the thrust.

were buckled downward and backward under the soft shales, as indicated by the arrows in II before they were also fractured. The lower limestones were also considerably broken and cross-faulted, as shown in the figures. The amount of displacement of the overthrust is about 100 feet. The force was exerted from the eastward and almost horizontally in direction, unless the present low angle between fault line and axial planes is due to subsequent tilting.

Down the creek from the overthrust the Hudson river shales are finely exposed, dipping steeply to the westward and unconformably overlaid by Helderberg beds which give rise to cliffs above. A mile below the fault the dip flattens considerably and in the center and eastern limb of this gentle synclinal of Helderberg limestones at the road metal quarry there is nearly perfect conformity between Hudson river sandstones and shales and the overlying limestones. This is only a local coincidence, however, for to the southeastward along the face of the Helderberg escarpment there is marked unconformity in the district west of Coeymans.

In this section on the plate the structure of the Hudson river rocks to the eastward is also shown, but this is intended to afford only an idea of the general features of the flexures, for owing to the heavy drift cover I was unable to ascertain the details.

Along the Hudson valley northward to Albany and beyond, the Hudson river rocks are steeply folded, probably also faulted and have an exceedingly complicated structure. Owing to the lack of distinct stratigraphy in the beds involved, to the rarity of extensive outcrops across the strike, and to the extreme contortion at all points, I was unable, in the time at my disposal, to work out the structure of the region. The contortion of the beds is exposed at many points near Albany, noticeably along the Norman's Kill near Kenwood, and southward along the West Shore railroad from "The Abbey" to Wemple. Along the Mohawk river there are many exposures of the flexed Hudson river beds. To the westward the flexures are gentle, but their steepness increases rapidly to the eastward, and at the great exposures at Cohoes falls the beds are seen to be steeply flexed and much contorted.

PLEISTOCENE GEOLOGY.

The pleistocene deposits of Albany county consist of accumulations of glacial materials, stratified clays and sands, dune sands

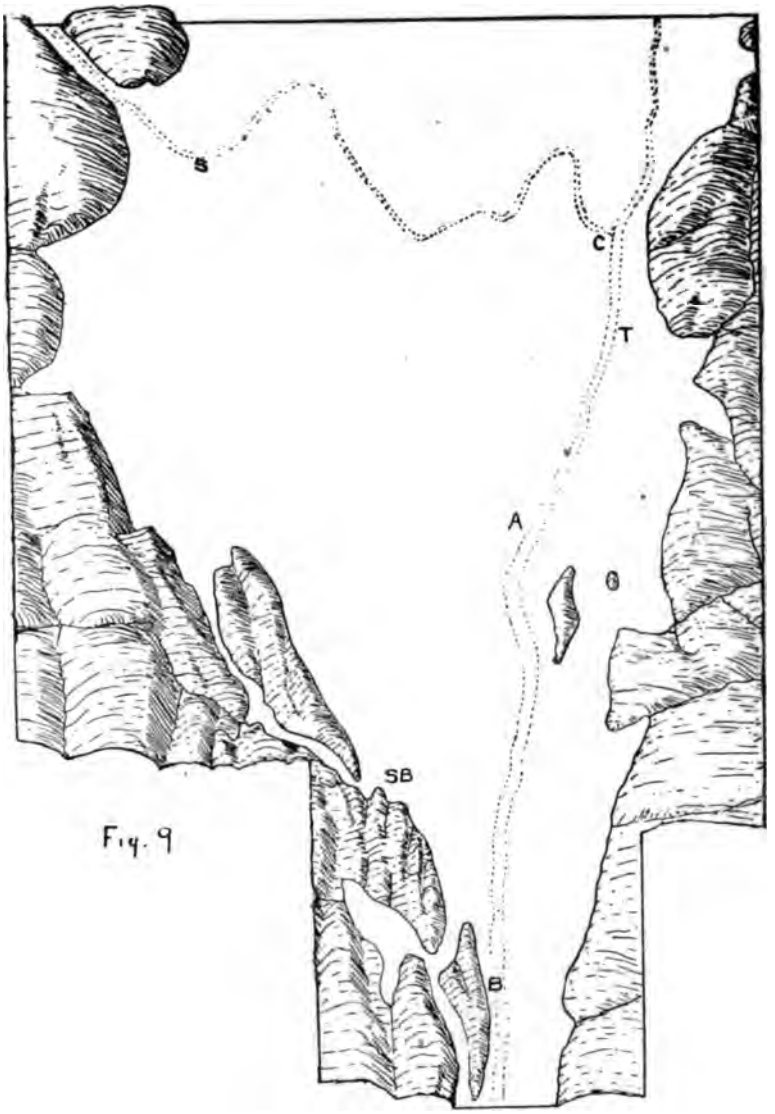


FIG. 9.— Stereogramic map showing the extent of the Champlain submergence in Albany and adjacent counties. Scale, seven miles to the inch. A., Albany; S., Schenectady; K., Altamont, C., Cohoes; T., Troy; S. B., South Bethlehem; B., New Baltimore. The course of the Hudson and Mohawk rivers is indicated by the dotted lines.